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Flood Hazard Assessment of the Eastern Region of Bangkok Floodplain, Thailand

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Abstract. This research aimed to study the uncertainty of flood hazard assessment for the eastern region of Bangkok floodplain in the surrounding area of the new Bangkok International Airport, Thailand. The study was focused on the comparison of flood hazard assessment from the hydrodynamic model simulation and the recent flood occurred in November 2011 within the study area. The results from the study provide a comparative study of the flood hazard zones from the hydrodynamic model simulation caused by 100 year rainfall in the study area and that from the actual flood caused by the 100-year rainfall over the Chao Phraya River Basin.

Keywords: Flood hazard assessment, Bangkok Floodplain, Suvarnabhumi International Airport

1. Introduction

Flood is one of frequent natural disasters that are catastrophic to human life and properties. It frequently occurs in many parts of the world and causes both tangible damage and intangible damage. Floods may be caused by accumulation of heavy precipitation within a particular area or the runoff from outside areas. The severity of flooding can range from flash flood to gradual increasing flood for longer duration which depends on magnitude or characteristics of precipitation/rainfall and topography of the flood affected areas. Proper measures of flood forecasting and warning system are crucial to provide information of spatial and time distribution of flood with flood duration and flood water level. A flood forecasting system requires hydrologic models and hydrodynamic models to forecast flood flow in waterways and floodplains.

Bangkok, the capital of Thailand has faced flood disasters several times during the last three decades, e.g. 1980, 1983, 1995 and 2011. It is located in the lower basin of the Chao Phraya River which is a natural floodplain due to its low-lying terrain. The presence of the new Bangkok International Airport so called the Suvarnabhumi International Airport and rapid urbanization of the surrounding area of the airport reduces the flood storage and drainage capacity of the surrounding area. This induces more adverse effect to the flooding situation.

Actually, we cannot afford to protect flooding at a very large magnitude and the extreme flood event is frequently neglected due to high cost of investment. Hence, a mitigation plan in case of occurrence of those extreme flood events is required. So, flood hazard assessments come as information for flood mitigation planning by establishing a proper flood protection, warning and evacuation system.

For long-term planning, it is essential to develop flood hazard maps and flood risk maps based on different probabilistic floods to identify priority for flood mitigation areas when budget is limited. This study determines the uncertainty of flood hazard assessment by comparing the flood hazard zones from different probabilistic floods. The study also determines the uncertainty of flood hazard assessment by comparing the flood hazard zones from hydrodynamic model and the actual flood occurred within the study area.

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2. Description of Study Area

The overall study area covers an area of 624 km^2 in the eastern floodplain of Bangkok and it is located in the surrounding area of Suvarnabhumi International Airport as shown in Fig 1. It is surrounded by Klong Saen Saeb (*klong* means canal) and Klong Nakorn Neung Khet in the north, Klong Phra-Ong Chao Chaiya Nuchit in the east until Sukhumvit Highway and Rom Klao-King Kaew Road in the west. These canals and roads can protect intrusion of storm runoff from outside areas into the study area. The south of the study area is adjacent to the Gulf of Thailand. The average ground elevation of this area is about + 0.40 m to + 1.00 m

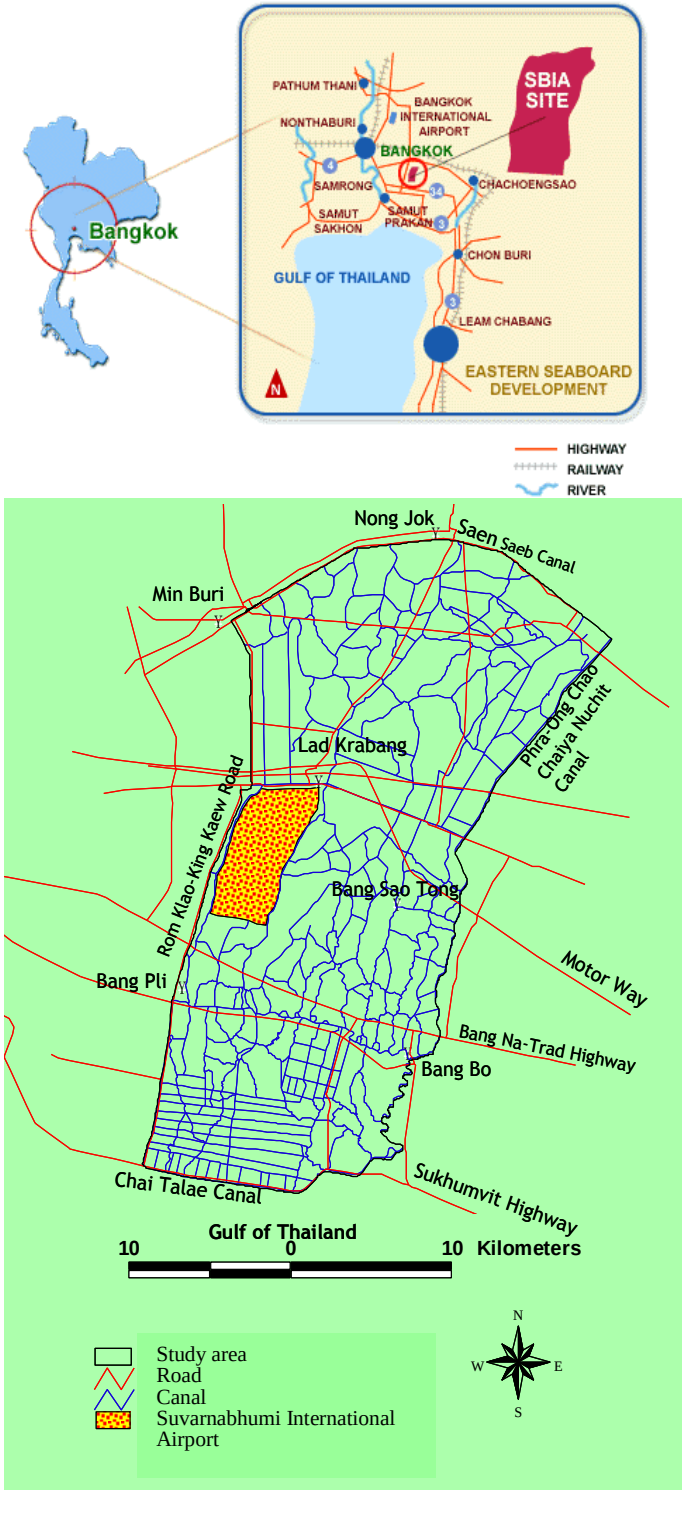

Fig. 1: Study area

above mean sea level and the topography of the area is a flat plain in which the water can drain out slowly. To protect the airport from flooding in critical situation, two pump stations in the south of the airport are installed to pump out flood water from the airport into the study area with overall capacity of 12 m^3/s. The climate of the study area belongs to the tropical monsoon type and the mean annual rainfall is approximately 1,234 mm [1]. The rainfall between May and October is about 89% of total annual rainfall.

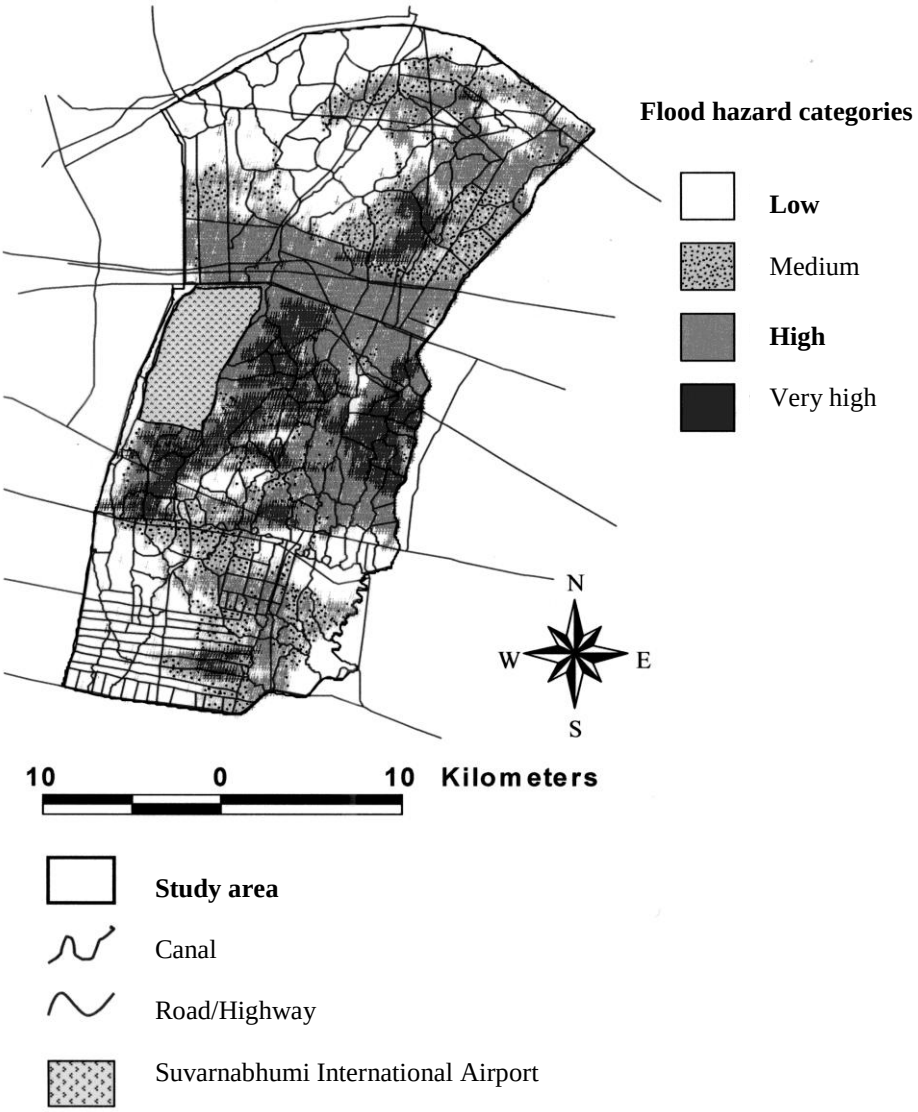

Fig. 2: Computed flood hazard map for 100-year return period of rainfall

3. Research Methodology

In the past few years, various researchers have used the hydrodynamic modeling approach to simulate flood inundation in many floodplains. Patro *et al*. [2] used a coupled 1D-2D hydrodynamic model, MIKE FLOOD to simulate the flood inundation extent and flood depth in the delta region of Mahanadi River Basin in India. Tingsanchali and Karim [3] used the MIKE-11 hydrodynamic model to simulate flood-wave propagation through the main channel and over the floodplain of the Yom River Basin to develop flood risk maps in northern Thailand.

This study compares the zoning-based flood hazard classification from the hydrodynamic model simulation and the actual flood in November 2011 which had a return period of rainfall about 100 years. As per the study by Keokhumcheng in 2012, a hydrodynamic model namely MIKE FLOOD model [4] was used to simulate the flood inundation in this study area. Since the surrounded canals and roads can protect the intrusion of storm runoff from outside into the study area, the simulation in this study was based on the

assumption that the inflow into the study area is directly from the accumulation of rainfall within the study area only. Initially, the hydrodynamic model was calibrated and verified using observed flood water level of the flood in 1995 at Bang Phli Watergate Station on Klong Samrong [1]. After model calibration and verification, the model was used to simulate the flood flow in terms of flood depth for 100-year return periods of rainfall. Flood hazard assessment which is the estimation of overall adverse effects of flooding in the study area was performed by classification the severity of flood depth and flood duration within the study area in term of flood hazard factors for different categories of flood depth and flood duration. Finally, the flood hazard map which represents the severity of flood hazard in the study area can be developed by the integration of flood hazard factors in each grid of the study area.

The actual flood occurred in the study area in November 2011 which was mainly caused by the unplanned diversion of storm runoff from outside into the study area. The available recorded data of flooding in the study area in November 2011 were examined to develop the actual flood map. The actual flood map in 2011 was compared with the obtained flood hazard map from the hydrodynamic model simulation.

Fig. 3: Actual flood inundation map in the study area in November 2011

4. Results and Discussion

In reference to the study of Keokhumcheng [5], the simulation of flood flow through the canal network and floodplain within study area due to accumulation of rainfall within the study area was performed by MIKE FLOOD Hydrodynamic Model for 100-year return period of rainfall. The simulation was performed for September and October 2011, which have the highest monthly rainfall. As previously described on flood hazard assessment and the result from the model simulation, the classification of the severity of flood hazard

based on the integration of flood depth and flood duration in term of flood hazard factors was performed and the flood hazard map can be developed as shown in Fig. 2. From the developed flood hazard map it was found that the northern part of the study area mostly belongs to low and medium flood hazard zone while the high and very high flood hazard zones are mostly found in the east and south of the airport. These are different from the actual flood situation in the study area in November 2011. As shown in Fig. 3 [6] the northern parts of study area were mostly affected by flood.

The actual flood in November 2011 inundated the northern and central Thailand outside the study area. Several districts in northern and western parts of Bangkok which lie outside Bangkok's flood wall were flooded heavily. In November 2011, diversion of the mentioned flood water into the study area was done to protect the center of Bangkok and hence, the northern parts of the study area were mostly affected by floods. The difference between the actual flood in November 2011 and that simulated by the model for the 100-year return period of rainfall in the study area is because the computed flood hazard by the model was determined based on direct rainfall occurs within the study area while the actual flood in 2011 was caused by intrusion of flood runoff from outside into the study area. Therefore, the flood hazard assessment by the model simulation based on 100-year rainfall in the study area is not the same as the flood hazard caused by intrusion of flood water from outside into the study area.

5. Conclusions

The main focus of this study is to compare the zoning-based flood hazard from hydrodynamic model simulation and from the actual flood in November 2011 in the study area which is surrounding the new Bangkok International Airport. The presence of the airport and rapid urbanization of the study area induce adverse effect to the flood situation. Because of high cost of investment, we cannot afford to prevent extreme flooding situations. So, flood hazard assessment comes as a solution to provide the necessary information for flood mitigation planning. The study was carried out by the assessment of flood hazard for 100-year return period of rainfall. The findings presented herein provide useful information about severity of flood hazard for different parts of the study area. From the hydrodynamic model simulation, it was found that, the high and very high flood hazard zones in the study area were mostly found in the east and south of the airport, particularly in housing estate areas and industrial areas since these areas are located in the depression area of the floodplain. These areas are also close to the airport and are directly affected by the water pumped out from the airport. While the medium and low hazard zones were mostly found farther from the airport especially in the north and south of the study area.

By consideration of the actual flood in November 2011, it was found that the inundation areas were mostly in the north of the study area. This is due to the intrusion of flood water from outside area into the study area in order to protect the center of Bangkok from flooding.

From the study it is also found that there are many factors other than the hydrologic parameters that affect the assessment of flood hazard. The major one is the floodplain management such as flood diversion.

Flood control operation can cause uncertainty in flood hazard assessment. It should also be noted that flood water needs space, once the areas have been protected from flooding, the water will automatically cause flood problem in other areas. To overcome this encumbrance, systematically basin-wide planning based on flood hazard assessment is necessary to develop an effective flood mitigation planning as a whole.

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